

Trends in Water Occupancy Rates of Gazibey Dam Lake During the 2020-2024 Period

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Abstract— Recently, climate change, one of the biggest problems of our time along with global warming, has emerged. This problem is increasing day by day in Turkey, as it is all over the world. This research examines the trends in water occupancy rates of the Gazibey Dam Lake in Sivas province, Turkey, during the period 2020-2024. In this research, the water occupancy rates data of the Gazibey Dam Lake, which was made accessible by the General Directorate of State Hydraulic Works of Turkey, was used. The water occupancy rates in Gazibey Dam Lake were determined as 42.3% in 2020, 31.4% in 2021, 5.0% in 2022, 18.0% in 2023, and 10.4% in 2024. In this study, the average annual water occupancy rate of Gazibey Dam Lake during the 2020-2024 period was calculated as $21.42 \pm 15.32\%$. Due to climate change and insufficient rainfall, water occupancy rates in Gazibey Dam Lake are steadily decreasing. Evaporation also results in insufficient total water entering the lake. These factors indicate that droughts are occurring more frequently in Gazibey Dam Lake due to climate change. The continued decrease in water occupancy rates in Gazibey Dam Lake, one of Sivas province's important water sources, will negatively impact agricultural production. Therefore, modern irrigation methods such as sprinkler and drip irrigation should be used to conserve water from Gazibey Dam Lake. When selecting crop patterns for future years, drought-resistant plants with low water requirements should be preferred.

Keywords— Agricultural Irrigation, Climate Change, Gazibey Dam Lake, Water Occupancy Rates.

I. INTRODUCTION

Water is essential for the sustainability of life. It is estimated that there are 1.4 billion cubic kilometers of water on Earth. The water contained within the Earth moves under the influence of solar energy and gravity. Living things need the available water directly or indirectly. Today, rapid population growth, agriculture, industry, and advanced technology are greatly increasing the need for water [1]. The survival, development, and continuation of life of societies in the world depend on water. Even in countries with sufficient freshwater resources, increasing demand, pollution, and overuse are jeopardizing water supply. In developing countries, the need for freshwater is steadily increasing due to

rapid growth in agriculture, industry, and urban development. With the potential effects of global warming and climatic changes in the world's water cycle, problems are compounded, and the future availability of usable freshwater is at greater risk than ever before [2]. The negative impacts on the lives of living things are increasing day by day. Environmental problems, which are not only regional but also universal, threaten the entire world, regardless of whether they are living or non-living. The interaction between climate and humans has been ongoing for centuries. Since the dawn of humanity, climate has influenced people's lifestyles and quality of life, as well as being affected by their various activities. Recently, the human-climate

interaction has begun to take a negative turn, favoring both sides. The increasing scale of human-induced environmental damage is negatively impacting nature's self-repair and renewal mechanisms. The world has experienced climate change at different times. However, particularly after the industrial revolution, increased human-caused environmental damage has disrupted the natural balance, and significant climate changes are being observed [3].

The most significant problem threatening the world today is global climate change. The increase in temperatures and drought due to climate change will affect Turkey's water resources. An examination of monthly rainfall and temperature distribution in Turkey over many years shows that temperatures increase during the summer months while rainfall decreases. On the other hand, evaporation also increases in proportion to the increase in temperature, affecting the volume of irrigation water and causing problems in agricultural production. Seasonal snow and snow cover areas will decrease, and the periods of snow cover will also shorten. In addition to the pressure exerted by rising temperatures on water resources, there is also pressure created by humans. In Turkey, the per capita annual available water amount was 1,652 cubic meters in 2000, decreasing to 1,544 cubic meters in 2009 and further to 1,346 cubic meters in 2020. These figures indicate that Turkey is among the countries experiencing water scarcity [4].

Climate change brings with it disruptions in rainfall patterns, melting glaciers, decreases in water resources, deterioration in water quality, degradation of terrestrial and aquatic ecosystems, and changes in geographical habitats. Changes in climate and climatic conditions, irregularities in rainfall patterns, and fluctuations in rainfall amounts affect agricultural practices. The insufficient amount of water in the soil, necessary for the growth and development of agricultural products, affects soil fertility and agricultural diversity. There are 3.2 billion hectares of arable land in the world. The per capita agricultural land is expected to be 0.15 hectares by 2025. These decreases will cause increases in product prices, seriously hindering access to food for the population [5].

The agricultural sector, which has a strategic position regarding climate change, is the sector most affected by even the slightest seasonal change. Since there will be no short-term reversal of the effects of climate change, one of the most important measures to be taken is to plant crops adapted to changing climate conditions [6].

The increasing frequency and severity of extreme climate events such as droughts and floods caused by climate change are negatively impacting agricultural production. Climate change is altering agricultural production methods, which reduces productivity and decreases the global food supply [7]. In response to the new conditions brought about by climate change, farmers will change the planting and sowing dates of crops by replacing existing species with newer ones that are better suited to the conditions. With the expected increase in temperatures, soil moisture loss and increased transpiration in plants will lead to an increase in the planting of drought-resistant species [5]. This research examines the trends in water occupancy rates of the Gazibey Dam Lake, constructed for agricultural irrigation and flood protection, during the period 2020-2024.

II. MATERIALS AND METHODS

Kılıçkaya Sivas province, located in the center of the Anatolian peninsula, is situated in the Central Anatolia Region. The Gazibey Dam Lake is located on the Osugölüç Stream in Sivas province. Construction of the Gazibey Dam, intended for irrigation and flood control, began in 1987 and was completed in 1992. The Gazibey Dam is a clay core, upstream permeable downstream rock fill dam type. Its height is 45.5 meters, and the lake area at normal water level is 5.74 square kilometers [8]. The volume of the Gazibey Dam Lake is 18,530,000 cubic meters, and it has a net irrigation area of 2,385 hectares. The amount of water drawn from the Gazibey Dam Lake is 2.52 cubic hectometers, while the amount of water added to the Gazibey Dam Lake is 5.2 cubic hectometers [9].

Turkey is a peninsula country located in the northern hemisphere, between Asia and Europe, surrounded by seas on three sides. It lies between the temperate and subtropical zones. Since the 1990s, Turkey has experienced an increase in temperatures and a

decrease in rainfall. Insufficient or excessive rainfall during certain seasons can trigger natural disasters such as floods or droughts. Irregularities in rainfall patterns lead to water scarcity. A positive trend in temperature increase has been observed in Turkey from 2007 to 2023. The average temperature in Turkey in 2023 was observed to be 1.2 degrees higher than the average temperatures of 1991 and 2020. The average annual areal rainfall in Turkey is recorded as 573.4 mm [5]. Gazibey Dam Lake is located in Sivas province. Sivas has a continental climate with hot and dry summers and very cold winters. Summer months in Sivas are very hot and dry, and the summer season is quite short. Winter months are cold, long, and snowy. Sivas is the coldest province in the Central Anatolia Region. Precipitation in Sivas occurs during the winter, spring, and autumn seasons. Summer is generally dry. The average annual rainfall is 420 mm. Sivas province contains habitats with different ecological characteristics, such as forest ecosystems, aquatic ecosystems, and steppe vegetation. In Sivas province, where steppe vegetation is dominant, Alpine steppes are prevalent at altitudes above the forest line. The total agricultural area of Sivas province is 955,722 hectares. Agricultural products grown in Sivas province include wheat, barley, rye, sugar beet, alfalfa, chickpeas, potatoes, and corn [9].

This research utilizes water occupancy rate data for the Gazibey Dam Lake, obtained from the General Directorate of State Hydraulic Works in Turkey, covering the period from 2020 to 2024 [10]. This study investigates the trends in water occupancy rate in Gazibey Dam Lake during the 2020-2024 period. Furthermore, this research provides a deeper understanding of the current state and future expectations regarding the water occupancy rate of the Gazibey Dam Lake. The minimum water occupancy rate in Gazibey Dam Lake is defined as the water intake structure elevation. The volume below this elevation is reserved for sediment material from the basin throughout the operating life of the Gazibey Dam, and this volume is called dead volume. The active volume refers to the volume between the minimum water level and the normal water level. Since the dead volume decreases throughout the operation of the Gazibey Dam Lake, and a separate pumping system is required to draw

water from this elevation, operational activities are planned according to the active volume. In Turkey, the General Directorate of State Hydraulic Works announces the water occupancy rate based on active volume. The water occupancy rate data for Gazibey Dam Lake is expressed as a percentage.

III. RESULTS AND DISCUSSION

Starting in 2020, a decreasing trend in water occupancy rates has been observed in Gazibey Dam Lake. The water occupancy rate in Gazibey Dam Lake, which meets the irrigation needs of 2385 hectares of net agricultural land in Sivas province, decreased from 42.3% in 2020 to 31.4% in 2021 and 5.0% in 2022. Similarly, it decreased from 18.0% in 2023 to 10.4% in 2024. Accordingly, the slope of water occupancy rates in Gazibey Dam Lake during the 2020-2024 period is downward (Figure 1).

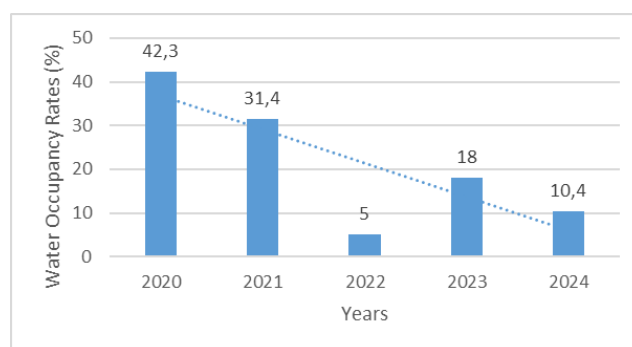


Fig. 1: Water occupancy rates and slope line of Gazibey Dam Lake.

In this study, the average annual water occupancy rate of Gazibey Dam Lake during the 2020-2024 period was calculated as 21.42 ± 15.32 percent. Divrik [11] reported the average water occupancy rate of Gazibey Dam Lake between 2010-2019 as 28.58 percent. Based on these average annual water occupancy rate results, it was determined that the average annual water level of Gazibey Dam Lake decreased by 7.16 percent in the 2020-2024 period following the 2010-2019 period. This shows that the decreasing trend in the water occupancy rates of Gazibey Dam Lake continues.

In recent years, studies conducted by Dirican [12], Dirican [13] and Dirican [14] respectively, in Maksutlu, Kılıçkaya and Yayıltın dam lakes, located in Sivas province where Gazibey Dam Lake is

situated, have reported a similar decreasing trend in water occupancy rates.

Climate change inevitably has a number of global and regional impacts. Indeed, global climate change is expected to affect agriculture, forests and vegetation, clean water resources, sea level, energy, human health, and biodiversity. All these negative impacts primarily worsen the living conditions of people who depend on agriculture for their livelihood. Subsequently, they can jeopardize food security and threaten the health of all people. Coping with these situations will only be possible by reducing the negative impacts of climate change on agriculture and adapting to these adverse conditions [7]. Climate change affects the agricultural sector in various ways, both directly and indirectly. The emergence of drought makes it difficult to meet water demand and directly affects the agricultural sector, which is the most water-intensive sector. The agricultural sector, which is critically important for the world's population, has a unique structure as an extremely sensitive field of activity, highly affected by economic, social, political, technological, and personal risks. The negative impacts and severity of climate change vary depending on location and circumstances, both for agriculture and many other sectors [15]. The most basic human need, nutrition, is met through agricultural activities. The realization and sustainability of agricultural production depend on water resources. Drought caused by rising temperatures brings about major problems in agricultural production. Decreased agricultural production and changes in production methods affect productivity. A decrease in agricultural productivity leads to famine and hunger. In addition to famine and hunger, the increase in epidemic diseases due to heat in underdeveloped countries could cause a global problem [16].

Due to the effects of global warming and climate change, the water sources feeding the Gazibey Dam Lake are gradually decreasing. The water occupancy rate in Gazibey Dam Lake, which reached its highest level of 42.3% in 2020, rapidly decreased to its lowest value of 5.0% in 2022 (Figure 1). Gazibey Dam Lake has an average annual water occupancy rate of 21.42% during the 2020-2024 period. As a result of climate change, the decrease in rainfall has caused the water occupancy rates in Gazibey Dam Lake to

decline, resulting in an average annual water occupancy rate of 21.42%. This shows that there has been a significant decrease in the water occupancy level in Gazibey Dam Lake due to the drought experienced in recent years.

Climate change continues to intensify its impact worldwide. The most significant losses caused by the effects of climate change occur in the agricultural sector. The effects of climate change may lead to significant reductions in yield and quality in agricultural production. These losses from crop production will cause future food crises and prevent people from accessing sufficient food. To prevent these losses, adaptation to climate change in agricultural production is paramount. For adaptation in agricultural production, it is necessary to cultivate crops that are resistant to drought and irregular rainfall in the region [6]. Factors such as less rainfall than in previous years and population growth as a result of climate change will negatively affect the amount of water used in production and consumption in the coming years. Since less rainfall may not be sufficient throughout the year, difficulties will arise in combating drought, especially during the summer months and in areas where irrigated agriculture is widespread [17]. The irrigation water problem caused by drought, low rainfall or destructive rainfall patterns, and dangerously high temperature extremes create significant problems. The world's climate is changing, and many agricultural products are unable to cope with it [15]. When agricultural products lack access to sufficient water, they may experience drying out, failure to grow, or lack of flowering. In this case, since the products produced domestically will not be sufficient, the necessary agricultural products will have to be imported. Ensuring food security is an important step in combating drought. Therefore, planning the storage and use of water is a crucial factor in long-term drought mitigation [18]. To minimize the effects of climate change on agricultural products, non-industrial, environmentally friendly agricultural practices should be used, products suitable for the climate and soil conditions should be preferred, artificial fertilization should be avoided as much as possible, and planting and harvesting dates should be planned in accordance with the conditions (Sarıçoban, 2025).

The total irrigable area in Sivas province is 291,166 hectares. Approximately 30% of the total agricultural land is irrigable. Considering that 135,635 hectares of the 291,166 hectares of irrigable land are actually irrigated, the irrigated area in operation is approximately 46% of the total identifiable irrigable area [9]. According to these figures, Gazibey Dam Lake contributes 1.22% to the total irrigable area of Sivas province with a net irrigated area of 2,385 hectares. Therefore, in the long term, the planning, storage, and efficient use of the water from Gazibey Dam Lake are of great importance in combating drought and ensuring sustainability.

IV. CONCLUSION

The Gazibey Dam Lake, completed in 1992, experienced its lowest water occupancy rate in 2022 at 5.0% during the 2020-2024 period. This water occupancy rate is the lowest recorded for the 2020-2024 period. This decrease in the water occupancy rate of the Gazibey Dam Lake is quite critical and dramatic. Furthermore, this research has determined that the water occupancy rate trend in Gazibey Dam Lake during the 2020-2024 period is downward, indicating a decrease. Due to the drought and decreasing water levels in Gazibey Dam Lake, agricultural production will be negatively impacted. To conserve water in Gazibey Dam Lake, sprinkler and drip irrigation methods should be used. When selecting crop patterns for the coming years, drought-resistant plants with low water requirements should be planted.

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